US Army Corps of Engineers®

Northwestern Division

2003 DISSOLVED GAS AND WATER TEMPERATURE MONITORING REPORT

COLUMBIA RIVER BASIN

McNary Forebay – Oregon Side Fixed Monitoring Station

North Pacific Water Management Division
Reservoir Control Center
Water Quality Unit

December 2003

DEPARTMENT OF THE ARMY
NORTHWESTERN DIVISION, CORPS OF ENGINEERS
P.O. BOX 2870
PORTLAND, OREGON 97208-2870

Reply to
Attention of:

December 19, 2003

North Pacific Water Management Division

Dear Interested Party,

Enclosed is the U.S. Army Corps of Engineers (Corps) 2003 Dissolved Gas and Temperature Monitoring Report, Columbia River Basin. It was prepared to describe operation of the Corps' mainstem projects on the Columbia and lower Snake River and reports on total dissolved gas and water temperature for 2003.

Please contact Mr. James Adams at (503) 808-3938 if you have any questions or comments.

Sincerely,

Cynthia A. Henriksen

Cynthia A. Henriksen
Chief, Reservoir Control Center

2003

U.S. ARMY CORPS OF ENGINEERS
DISSOLVED GAS AND WATER TEMPERATURE MONITORING REPORT

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Water Quality Unit
Reservoir Control Center, North Pacific Water Management Division
U. S. Army Corps of Engineers Northwest Division
Portland, Oregon

Including Material Provided by:
Portland District-US Geological Survey
Engineering Research and Development Center
Walla Walla District – HDR Consulting
Seattle District – Common Sensing Co.
Fish Passage Center

2003 DISSOLVED GAS AND WATER TEMERATURE MONITORING COLUMBIA RIVER BASIN

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List of Acronyms

The following acronyms are used throughout this report.

BiOp = Biological Opinion
Cfs = cubic feet per second
Corps = US Army Corps of Engineers
CRT = Columbia River Treaty
ESA = Endangered Species Act
FCRPS = Federal Columbia River Power System
FMS = fixed monitoring station
FPE = Fish Passage Efficiency
FPP = Fish Passage Plan
Kcfs = thousand cubic feet per second
Maf = Million acre feet
NMFS = National Marine Fisheries Service
NOAA Fisheries = National Oceanic and Atmospheric Agency, Fisheries
PUDs = Public Utility Districts
RO = regulating outlets
ROCASOD = Record of Consultation and Summary Decision
ROD = Record of Decision
RPA = Reasonable and Prudent Alternative listed in the Biological Opinion
RSW = removable spillway weir
TDG = total dissolved gas
TMT = Technical Management Team
TMDLs = Total Daily Maximum Loads
USF&WS = United States Fish and Wildlife Service
VARQ = Variable Q which means a variable flow associated with Libby flood control
WDOE Washington Department of Ecology

Terminology

The Corps has noted different agencies applying various definitions to common terminology. The following are the Corps definitions, which are used throughout this report and the 2003 Water Management Plan.

Voluntary Spill: Passing water through a project (either over the spillway or through regulating outlets (RO's) to assist juvenile salmon passage past dam projects in the Lower Columbia and Lower Snake rivers. Voluntary spill is done to decrease the residence time of juvenile salmon in the forebay of dams, which increases their passage and survival in the FCRPS. Spill, as a fish passage strategy, has a higher survival rate than most other routes of passage at the dam. The amount of voluntary spill is adjusted so that the resulting TDG levels associated with spill are consistent with applicable State water quality criteria.

Another reason for voluntary spill is for flow augmentation. The National Marine Fisheries Service (NMFS) and United States Fish and Wildlife Service (USF&WS) BiOps call for flow augmentation in the Columbia and Snake rivers. There are instances where spill at some projects is required to obtain the flow objectives called for in these BiOps.

Involuntary Spill: Involuntary spill is caused primarily by project and/or system operational limitations. There are two primary causes for involuntary spill:

1. When hydrologic conditions result in flows which exceed the hydraulic capacity of power generation facilities, and

2. When potential power generation from above average water supplies exceeds the available market, especially during light market hours at night and on weekends.

Other causes for involuntary spill include management of reservoirs for flood control, scheduled or unscheduled turbine unit outages of various durations, passing debris, or any other operational and/or maintenance activities required to manage project facilities. For example, in managing the project for flood control, the water supply forecast may underestimate the seasonal streamflows and cause the project operators to leave too little space in the reservoirs to catch the water. In other instances, unusually high winter precipitation may force the operators to store water in the reservoirs above the flood control elevations, causing involuntary spill to occur later as the water is evacuated to get to the reservoir flood control elevations.

Intertie Line Derating: The intertie line is the transmission system that transfers electricity between the Pacific Northwest and California. It is derated when its ability to transfer the electricity is decreased due to stability, thermal or environmental factors.

Unit Outage: A unit outage is a period of time when a generating unit cannot be in operation because of maintenance or repairs.

Lack of Load: There is a lack of customer need for power resulting in a lack of market for electricity generated.

TDG Exceedance: The definition for TDG exceedance varies with the state standards.

Idaho: A TDG exceedance is any hourly reading that exceeds 110% in the tailwater.

Oregon: There are two definitions of a TDG exceedance in the State of Oregon: exceedances that occur during spill season (April 1 through August 31) and exceedances outside of spill season. The standards do not apply when stream flow exceeds the seven-day ten-year frequency flood (7Q10).

1. Spill Season exceedance: A spill season TDG exceedance occurs when the average of the highest twelve hourly TDG readings during a single day exceeds 120% in the tailraces of McNary, John Day, The Dalles, and Boneville dams' monitoring stations or 115% in the forebays of McNary, John Day, The Dalles, and Bonneville Dams, and at the Camus/Washougal monitoring stations, or when the average of the highest two hourly TDG readings during a single day exceeds 125% at any of the above monitoring stations.

2. Non - Spill Season exceedance: A non-spill season TDG exceedance occurs when any single TDG reading exceeds 110%.

Washington: There are two definitions of a TDG exceedance in the State of Washington: exceedances due to operations associated with fish passage and operations not associated with fish passage exceedances. The standards do not apply when the stream flow exceeds the seven-day, ten-year frequency flood (7Q10).

1. Spill for fish passage exceedance: A TDG exceedance occurs during any operation associated with fish passage when the average of the highest twelve hourly TDG readings during a single day exceeds 120% in project tailraces or 115% in project forebays, or when a single hourly TDG reading exceeds 125%.

2. Non – fish passage exceedance: A TDG exceedance occurs during any operation not associated with fish passage when the average of the highest twelve hourly TDG readings during a single day exceeds 110% at any point of measurement.

TMT: TMT is an interagency adaptive management group that makes recommendations on operations for the Columbia/Snake system for the benefit of listed fish species. TMT consists of representatives from five U.S. federal agencies, the four states of Oregon, Washington, Idaho and Montana, and invitation of membership was extended to Columbia Basin Tribes.

Part 1 Program Description

1.1. Clean Water Act and Endangered Species Act

1.1.1 General

This report describes the Corps' Columbia River Basin Water Quality Monitoring Program for 2003 spill season and was developed to meet the Corps water quality program responsibilities. The report provides information consistent with the total dissolved gas variance issued by the state of Oregon and the rule modification by the state of Washington, meeting the objectives of the Reasonable and Prudent Alternatives of the National Marine Fisheries Service 2000 Biological Opinion.

The report focuses on the water quality monitoring of total dissolved gas (TDG) and temperature at the US Army Corps of Engineers (Corps) dams in the Columbia River Basin. The monitoring is part of a larger interagency water quality monitoring system operated by the Corps that includes the Corps' monitoring system, a US Bureau of Reclamation monitoring system, and Washington Public Utility District monitoring systems.

Of the 31 Federal Columbia River Power System (FCRPS) dams, 11 are included in this report [Bonneville; The Dalles; John Day; McNary; Chief Joseph; Libby; Ice Harbor; Lower Monumental; Little Goose; Lower Granite and Dworshak].The Corps' water quality monitoring program at these FCRPS dams is to: 1) monitor project performance in relation to water quality standards, and 2) provide water quality data for anadromous fish passage at Columbia/Snake mainstem dams. The monitoring program is considered an integral part of the Corps' Reservoir Control Center water management activities.

Total dissolved gas (TDG) and water temperature are the primary water quality parameters monitored in the mainstem Columbia and Snake rivers in the states of Idaho, Oregon and Washington. Both TDG and water temperature may be influenced by project water management operations (e.g. water released over the dam spillways, releases through the powerhouses and other facilities, and forebay and tailwater water surface elevations).

1.1.2 Corps Goals

It is the policy of the Corps of Engineers is to comply with water quality standards to the extent practicable regarding nationwide operation of water resources projects. "Although water quality legislation does not require permits for discharges from reservoirs, downstream water quality standards should be met whenever possible. When releases are found to be incompatible with state standards they should be studied to establish an appropriate course of action for upgrading release quality, for the opportunity to improve water quality in support of ecosystem restoration, or for otherwise meeting their potential to best serve downstream needs. Any physical or operational modification to a project (for purposes other than water quality) shall not degrade water quality in the reservoir or project discharges" (Section 18-3.b, page 18-5). The general policies of the Corps are

summarized in the **Corps Digest of Water Resources Policies and Authorities**, Engineering Pamphlet 1165-2-1, dated 30 July 1999.

1.1.3 Biological Opinion (BiOp)

1.1.3.1 Background

The data from the Corps Dissolved Gas Monitoring Program before 1984 was used to monitor consistency with water quality standards. In 1984, the Corps Dissolved Gas Monitoring Program was enhanced to serve the dual purposes stated in Section 1.1.1.

With the listing of certain Snake River salmonids in 1991 under the Endangered Species Act (ESA), the Corps implemented a variety of operational and structural measures to improve the survival of listed stocks. The NMFS1992 BiOp called for providing summer releases of available water for flow augmentation for migrating juvenile salmon. Spill for fish at the lower Snake River projects was limited to Lower Monumental and Ice Harbor dams. In 1994, the program was further expanded in response to the NMFS request to release water over the spillways at the lower eight Columbia and Snake rivers mainstem dams to a level of 120% TDG where state rule modifications, variances or waivers had been provided. This spill level has become an annual operation for the benefit of listed juvenile fish.

Water management operations to reduce water temperature in the lower Snake River for the benefit of adult Snake River fall Chinook salmon were also considered. The NMFS BiOps concluded that although the priority for cool water releases from Dworshak Dam were for migrating juvenile fall Chinook in July and August, releases to reduce water temperatures in September could be considered on an annual basis through the Regional Forum Process.

1.1.3.2 2000 BiOp

The Final 2000 NMFS and FWS Biological Opinions states:

"The two agencies intend the recommendations and requirements of these opinions to be mutually consistent. They represent the federal biological resource agencies' recommendations of measures that are most likely to ensure the survival and recovery of all listed species and that are within the current authorities of the Action Agencies."

USFWS BiOp

According to the USFWS 2000 BiOp, operational and structural changes are to be made to reduce uncontrolled spill and the effects of high levels of TDG at lower Columbia River dams if it is determined that bull trout are affected by the Federal Columbia River Power System (FCRPS).

NMFS BiOp

The NMFS 2000 BiOp identified metrics that are indicative of juvenile fish survival to meet system-wide performance objectives consistent with actions likely to avoid jeopardizing the continued existence of 12 listed fish species in the Columbia River Basin.

To achieve the objectives of the BiOp, NMFS developed the jeopardy analysis framework. It was recognized that, in many instances, actions taken for the conservation of ESA-listed species also move toward attainment of State TDG and water temperature standards. There are 14 actions (RPA's 130 to 143) identified as part of a water quality strategy in the NMFS 2000 BiOp. Specifically, RPA actions 131 and 132 deal with water quality monitoring. RPA action 131 indicates that the physical and biological monitoring programs are to be developed in consultation with the Regional Water Quality Team and the Mid-Columbia Public Utility Districts (PUD's). RPA action 132 specifies that a plan must be developed to perform a systematic review and evaluation of the TDG fixed monitoring stations (FMSs) in the forebays of all the mainstem Columbia and Snake River dams.

1.1.4 TDG Variance

One of the components of the NMFS 2000 BiOp water quality strategy was for the Corps to take the actions necessary to implement the spill program at the dams called for in RPA 54 BiOp, including obtaining variances from appropriate State water quality agencies. The Corps took the actions necessary for the 2003 spill season. Spill season is from April 3rd through August 31st as defined in the NMFS 2000 Biological Opinion.

The Corps obtained total dissolved gas variances with the States impacted by the program implemented in the Federal Columbia River Power System (FCRPS) for which the Corps has responsibility. As a long-term strategy, the Corps opened discussions about the process of pursuing long-term variances from the entities involved, with the intent of replacing the year-to-year processes.

As long-term variances are being worked into the regional planning process, the Corps pursued the following actions to obtain a 2003 variance from the State of Idaho, Oregon, and Washington for juvenile fish passage spill. Juvenile fish passage spill is spill at the four lower Snake River and four lower Columbia River to aid juvenile fish passage and spill at Dworshak to augment flows for juvenile fish passage.

1.1.4.1 State of Idaho

The Corps operated the Dworshak dam to the 110% Idaho standard for TDG in 2002-2003 and is expected to continue such operation into 2004.

1.1.4.2 State of Oregon

In the Corps' report on the 2002 TDG monitoring program provided to the Oregon Department of Environmental Quality on December 23, 2002, a request for a multi-year variance was also included in the submittal. The Oregon Environmental Quality Commission met on March 11, 2003 and approved the Corps' request subject to specific conditions on March 14, 2003. A variance of the TDG standard for the Columbia River was provided from midnight on April 1 to midnight August 31 for each spill season. The Commission approved a TDG standard for the Columbia River of a daily (12 highest hours) average of 115% as measured in the forebays of McNary, John Day, The Dalles, and Bonneville dams, and at the Camas/Washougal monitoring stations, an average of

120% as measured at the McNary, John Day, The Dalles, and Bonneville dams tailwater monitoring stations, and 125%, based on the highest two hours per calendar day. The Commission also indicated that if 15% of the juvenile fish examined showed signs of gas bubble disease in their non-paired fins, where more than 25% of the surface area of the fin was occluded by gas bubbles, the spill variance would be terminated.

The Corps was asked to provide written notice within 24 hours to the Oregon Department of Environmental Quality on any exceedances of the conditions in the variance as it relates to voluntary spill. The Corps is to provide an annual year-end TDG report for each spill season by the end of the calendar year of that spill season. This report shall supply information on the levels of TDG, the fish monitoring, and incidence and severity of gas bubble disease.

1.1.4.3 State of Washington

A report of the 2002 TDG monitoring program was provided to the Washington Department of Ecology (WDOE) on December 23, 2002 that also included a request for a 5-year exemption from the TDG standards for the spill seasons 2003 through 2007. A letter was provided to the Corps signed on March 18, 2003 by WDOE approving the Corps gas abatement plan for all activities related to fish passage at the Columbia and Snake River dams for a period of one year. This provides for spill at Bonneville, the Dalles, John Day, McNary, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dams to aid fish passage, and Chief Joseph operations to manage system spill for improved fish conditions, may raise dissolved gas levels above 110% saturation but not exceed 125% saturation as a one hour average. Gas saturation may not exceed 120% in the tailrace and 115% in the forebay as measured at the fixed monitoring stations as an average of the 12 highest readings in any single day. The Corps is to continue to evaluate, refine, and implement gas abatement activities, continue programs for biological trauma monitoring for gas effects and physical monitoring for TDG, reporting any changes or modifications to the December 2003 gas abatement plan by August 31, 2003, and submit an Annual Report of the physical and biological monitoring and a Revised Gas Abatement Plan by February 27, 2004.

1.1.5 Operating Guidelines

The Water Quality Team of the Corps Reservoir Control Center is responsible for monitoring the TDG and water temperature conditions in the forebays and the tailwaters of the lower Columbia River/Lower Snake River dams, and selected river sites. The operational water management guidelines in Oregon are to change spill levels and, subsequently, spill patterns at the dams (daily if necessary) so that the forebays are as close to, but do not exceed, daily (12 highest hours) average of 115% TDG, and the tailwater levels are close to, but do not exceed, daily (12 highest hours) average of 120% TDG. When these adjustments are made, the water volume, water elevation (where applicable), project powerhouse and spillway characteristics (where applicable), and short- and long-term weather forecasts were included in the evaluation.

1.2 Monitoring Stations

TDG and temperature are monitored throughout the Columbia River Basin using FMSs (fixed monitoring stations). There are a total of 41 FMSs in the U. S. portion of the Columbia River basin. The Skamania station, downstream of Bonneville dam was not operated in 2002 or 2003, because another nearby location at Corbett, Oregon was being tested as a possible replacement site. The U. S. Bureau of Reclamation, Chelan and Grant County PUDs maintain four stations each. Two stations are maintained by Douglas County PUD. The Corps maintained the remaining stations. Appendix A contains general information about each FMS and a map of their locations.

1.3 Monitoring Plan of Action

The Corps prepares a dissolved gas Plan of Action each year. It is a supporting document for the NMFS Regional Forum Technical Management Team (TMT) to make recommendations on dam and reservoir operations. A web site description of the TMT can be found at:

http://www.nwd-wc.usace.army.mil/TMT/

The 2003 Plan of Action can be found listed under the TDG category of the Reservoir Control Center Water Quality Team page on the following web site:

http://www.nwd-wc.usace.army.mil/TMT/wqwebpage/mainpage.htm

The Monitoring Plan of Action for 2003 is also attached as Appendix B. The Plan summarizes the roles and responsibilities of the Corps as they relate to dissolved gas monitoring. The Plan stipulates what to measure, how, where, and when to take the measurements and how to analyze and interpret the resulting data. The Plan also provides for periodic review and alteration or redirection of efforts when monitoring results and/or new information from other sources justifies a change. The Plan identifies channels of communications with other cooperating agencies and interested parties.

Part 2 Program Operating Conditions

2.1. Water Year Runoff Conditions

2.1.1 Weather

The 2003 Water Year, which began in October 2002, was cooler than normal temperature and below average in precipitation. The cumulative precipitation during water year 2003 in the upper Columbia River Basin was 80 percent of normal (1971-2000) above Grand Coulee Dam, 89 percent of normal in the Snake River above Ice Harbor Dam, and 85 percent of normal in the Columbia River above The Dallas, Oregon (Western Region Climate Center). The following month-by-month discussion of the weather provides more detailed information.

October 2002, at the beginning of the water year, was cooler than average. A ridge of high pressure off the Pacific Northwest coast was the dominant weather feature through much of October. Any weather disturbances that managed to break through this blocking ridge were weak and dropped only light precipitation across the region. Precipitation in October was 30 percent of normal (1971-2000) at the Columbia River above Grand Coulee, 44 percent of normal at the Snake River above Ice Harbor, and 33 percent at the Columbia River above The Dalles. For the 31-station temperature index for the Pacific Northwest, regional temperature departed -1.8 degrees Celsius (-3.2 degrees Fahrenheit) from normal relative to the 1971-2000 normals. Mean temperature departures ranged from -3.6 to -0.1 degrees Celsius (-6.5 to -0.1 degrees Fahrenheit).

Although the second week of November brought a series of Pacific storms, high pressure was the dominant weather feature most of the month, resulting in well below normal precipitation across the region. November precipitation was: 64 percent of normal (1971-2000) at the Columbia River above Grand Coulee, 55 percent of normal at the Snake River above Ice Harbor, and 57 percent at the Columbia River above The Dalles. The regional temperature index for the Pacific Northwest departed 0.7 degrees Celsius (1.2 degrees Fahrenheit) from normal in November.

December 2002 was a continuation of seasonal warm weather. December precipitation was: 93 percent of normal at the Columbia River above Grand Coulee, 101 percent of normal at the Snake River above Ice Harbor, and 102 percent at the Columbia River above The Dalles. The warm weather was characterized by a Pacific Northwest temperature departure of 2.9 degrees Celsius (5.2 degrees Fahrenheit) from normal, and mean temperature departures ranging from 0.9 to 4.1 degrees Celsius (1.7 to 7.3 degrees Fahrenheit).

January 2003 temperature continued to be warm. The 31-station temperature index for the Pacific Northwest departed 4.1 degrees Celsius (+7.3 degrees Fahrenheit) from normal in January. January was the second warmest January on record for several cities, including Seattle, WA and Pocatello, ID. Early in the month the main storm track occasionally dipped south of the U.S.-Canadian border. This brought above normal precipitation to far northern tier basins, but left the rest of the region drier than normal. Late in the month, heavier precipitation fell across most areas as storm systems with access to tropical moisture moved into the Pacific Northwest. January precipitation was: 101 percent of normal at the Columbia River above Grand Coulee, 120 percent of normal at the Snake River above Ice Harbor, and 116 percent at the Columbia River above The Dalles. The 31-station temperature index for the Pacific Northwest departed 4.1 degrees Celsius (+7.3 degrees Fahrenheit) from normal in January, where mean temperature departures ranged from 2.4 to 5.9 degrees Celsius (4.4 to 10.6 degrees Fahrenheit).

Early in February 2003 the subtropical jet remained positioned across the Southern U.S. leaving the Pacific Northwest under the influence of high pressure and drier than normal weather. The polar jet moved farther south late in the month, allowing a series of frontal systems to bring periods of light to moderate precipitation to the region. February precipitation was: 54 percent of normal at the Columbia River above Grand Coulee,

89 percent of normal at the Snake River above Ice Harbor, and 69 percent at the Columbia River above The Dalles. The temperature index departed slightly above normal.

The month of March 2003 began dry and became wet as the month progressed. A wetter weather regime dominated through the latter part of the month as a ridge of high pressure in the Gulf of Alaska weakened and flow at upper levels became more zonal. Moderate to heavy precipitation events were experienced on the 6th-8th, 12th-14th, and 21st-22nd of March. The change is characterized by the monthly precipitation summary, where: Grand Coulee was 200 percent of normal, The Snake River at Ice Harbor was 134 percent of normal, and The Dalles 175 percent in March. The temperature index for the Pacific Northwest departed 0.8 degrees Celsius (+1.5 degrees Fahrenheit) from normal in March.

April remained wet, but cool. April precipitation was: 123 percent of normal above Grand Coulee, 143 percent of normal above Ice Harbor, and 130 percent above The Dalles. A daily precipitation record was broken in April at Yakima, WA when it received 0.64 inches of rain on the 26th. The 31-station temperature index for the Pacific Northwest departed –0.2 degrees Celsius (-0.3 degrees Fahrenheit) from normal relative to the 1971-2000 normals. Mean temperature departures ranged from -1.7 to 1.9 degrees Celsius (-3.0 to 3.4 degrees Fahrenheit).

During the month of May, the region returned to drier and warmer than normal conditions. May precipitation was: 82 percent, 94 percent, and 85 percent of normal at Grand Coulee, Ice Harbor and The Dalles, respectively. The temperature index was near normal with departure of only –0.1 degrees Celsius (-0.1 degrees Fahrenheit) from normal, where mean temperature departures ranged from -1.4 to 1.7 degrees Celsius (-2.5 to 3.0 degrees Fahrenheit).

The month of June kept the region in a dry warm weather pattern. June was drier than May with precipitation of: 69 percent of normal above Grand Coulee, 38 percent of normal above Ice Harbor, and 50 percent above The Dalles. The warm conditions were quantified by a temperature index departure of 1.2 degrees Celsius (+2.2 degrees Fahrenheit) from normal in June.

July was very dry. July precipitation was: 18 percent of normal (1971-2000) at the Columbia River above Grand Coulee, 36 percent of normal at the Snake River above Ice Harbor, and 20 percent of normal at the Columbia River above The Dalles. July temperature departures remained above normal at 2.7 degrees Celsius (+4.9 degrees Fahrenheit).

August continued very dry and warm. The precipitation was only 32 percent, 107 percent and 56 percent of normal at Grand Coulee, Ice harbor and The Dalles, respectively. Although Ice Harbor precipitation was 107 percent of normal, normal precipitation is only 0.86 inches during August. The 31-station temperature index for the Pacific Northwest departed 1.7 degrees Celsius (+3.0 degrees Fahrenheit) from normal relative to the 1971-2000 normals. Mean temperature departures ranged from –0.2 to 3.7 degrees Celsius (-0.3 to 6.7 degrees Fahrenheit).

In September, the upper level high held for at least part of the month, but the storm track punched inland temporarily. This allowed a series of fronts to bring some precipitation into portions of the Basin. Precipitation was 92 percent of normal at the Columbia River above Grand Coulee and 83 percent of normal at the Columbia River above The Dalles. September was a warm month, with record high temperatures at Portland of 35 degrees Celsius (95 degrees Fahrenheit) and Pendleton of 37.8 degrees Celsius (100 degrees Fahrenheit). The 31-station temperature index for the Basin departed +1.3 degrees Celsius (+2.3 degrees Fahrenheit).

2.1.2 Streamflow

The April 1, 2003 forecast of January through July runoff for the Columbia River above The Dalles was 105.2 km^3 (85.3 Maf) and the actual observed runoff was 108.2 km^3 (87.7 Maf). The actual observed runoff for the Columbia River was 87.7 Maf or 83 % of the 1971-2000 average. The average January-July runoff for the 1971-2000 period was 132.35 km^3 (107.3 Maf).

Precipitation was much below normal through the fall and the end of the calendar 2002 year. Only March and April of 2003 experienced more normal precipitation and increased streamflow. However this did not significantly influence the overall water supply. The unregulated runoff from January through July was 108.2 km^3 (87.7 Maf) at The Dalles, 82 percent of the 1971-2000 average. The unregulated runoff for 2003 peak unregulated flow at The Dalles was 16,772 cubic meters per second (m^3/s) (592,300 cubic feet per second (cfs)) on 1 June 2003 and a regulated peak flow of 10,944 m^3/s (386,500 cfs) occurred on 31 May 2003.

The Columbia River was operated to meet chum needs below Bonneville Dam from 5 November 2002 through May 2003. The lower Columbia River flow was regulated for juvenile fish between April 3 and August 31 based on recommendations of the TMT. The reservoirs were operated to target the 10 April flood control elevation per the NMFS 2000 BiOp for juvenile fish needs. For 2003 Libby Dam conducted an operation that focused on the Kootenai River white sturgeon larvae in conjunction with standard sturgeon pulsing operation to enhance spawning. The storage projects refilled by 30 June 2003. Projects were then drafted to the NMFS 2000 BiOp draft limits for 31 August, except for Dworshak Dam, which reached the draft limit in September.

Composite unregulated streamflow in the basin above The Dalles was generally below average through the winter months. There were some flows above average in early February and April 2003. Although the peak flow of the freshet was slightly above average at The Dalles, unregulated flow quickly receded and July and August streamflow of 2003 were well below average. July unregulated flow was 12.21 km^3 (9.930 Maf), 63% of average, and August unregulated flow was 6.94 km^3 (5.642 Maf), 67% of average. This was the fourth lowest July unregulated flow based on the period 1928 – 1988 and the lowest August flow based on the same period. The 2002-03 monthly-unregulated (natural) streamflows and their percentage of the 1971-2000 average monthly flows are shown in Table 1 for the Columbia River at Grand Coulee and The Dalles. These flows have been corrected to exclude the effects of regulation provided by storage reservoirs.

TABLE 1
COLUMBIA RIVER FLOWS
IN 2002 – 2003

	At Grand Coulee (in cfs)		At The Dalles (in cfs)	
Time Period	**Natural Flow**	**% of Average**	**Natural Flow**	**% of Average**
August-02	79,195	75	102,199	74
September-02	48,990	79	72,222	77
October-02	28,315	63	53,828	65
November-02	27,222	56	56,768	60
December-02	29,521	68	57,608	58
January-03	32,877	78	78,152	76
February-03	38,023	80	102,146	84
March-03	69,127	111	153,232	95
April-03	127,946	104	212,871	92
May-03	205,963	77	334,425	77
June-03	294,158	95	414,192	88
July-03	131,916	69	161,779	63
August-03	72,190	69	91,919	67
September-03	42,087	68	61,784	66
Operating Year Average (Oct 02 – Sep 03)	91,710	81	148,350	78

1.3 Reservoir Operation

2.1.3.1 General

The 2002-2003 operating year began with the system more than 90 percent full. The fall season through December was characterized by dry weather and below average snowpack. As a result, the January water supply forecast at The Dalles for the period January through July was only 80.5 Maf (76 percent) of average. This was a similar forecast to the drought year of 2001. Although 2003 continued to be dry, the water supply forecasts did not vary significantly. March and April were characterized by more precipitation, but they did not contribute to the snowpack component of the water supply and therefore the seasonal water supply at The Dalles was only 87.7 Maf (82 percent) of average for January through July.

The Federal system was operated to meet the needs of listed chum downstream of Bonneville Dam beginning 6 November 2002. The operation meant maintaining the tailwater elevation at Bonneville Dam at, or above, elevation 11.3 feet, so as to keep the areas downstream of Bonneville wetted while the chum moved into the area and spawned. This tailwater elevation was the minimum allowable to Bonneville through the emergence of the chum in May.

Operations consistent with the National Marine Fisheries Service, (now referred to as"NOAA Fisheries") BiOp, and the US Fish and Wildlife Service BiOp were completed in 2002-2003. The operations included refilling reservoirs to the 10 April flood control elevation. If inflow was great enough, refill on, or about, 30 June; and drafting reservoirs to summer draft limits. Because March and April were somewhat wet, the spring flow objectives at Priest Rapids, Lower Granite, and McNary were met. Spill was executed for spring and summer 2003 at all projects, and the Lower Snake River projects were operated at, or near, their minimum operating pools for the season.

2.1.3.2 Flood Control

With the 2003 water supply forecasts well below average across the Columbia River Basin, the reservoir system, including the Columbia River Treaty (CRT) projects required minimal draft for flood control in preparation for the spring freshet. Inflow forecasts and end of month flood control elevation targets were calculated monthly throughout the spring. Projects were operated according to the 2000 Flood Control Operating Plan. Although Libby operated to Variable Q (VARQ) flood control in 2003, the inflow was well below minimum outflow of 4 kcfs and the reservoir could not refill to the VARQ flood control elevation. Nor would the reservoir had filled to CRT 63 flood control elevation. Libby spill and TDG information are discussed in Appendix K. The unregulated peak flow at The Dalles, OR was estimated at 16,772 m^3/s (592,330 cfs) on June 1, 2003 and a regulated day average peak flow of 10,024 m^3/s (354,200 cfs) occurred on 31 May 2003. The unregulated peak stage at Vancouver, WA was calculated to be 6.34 m (20.8 feet) on 2 June 2003 and the highest-observed stage was 4.25 m (14.0 feet) on 1 February 2003.

In the 2003 spill season, there was one large peak runoff period characterized by greater than 350 kcfs total river flow, which prompted spilling for flood control. The peaks occurred on May 25 through June 18. The BiOp spill graphs in Appendix F illustrate the effects the one large peak runoff period had on voluntary and involuntary spill at the various projects. During the peak runoff period, all the projects had involuntary spill since the river flow exceeded generation capacity.

2.2 Water Releases

2.2.1 Spill

Spring Spill

The spring spill program in the Snake River started on April 3 for Lower Granite, April 5 for Little Goose, April 7 for Lower Monumental and April 9 for Ice Harbor. The spring spill program ended on June 20. Total river flow on the Snake was high (between 80 and 200 kcfs) from mid-May to mid-June, when flow began to taper off. There was voluntary spill for juvenile fish passage at all the Snake River projects. Managing spill at the Lower Monumental was constrained somewhat by the TDG levels in the Ice Harbor forebay. Of

the Columbia and Snake River projects, Ice Harbor forebay had the most exceedances with a total of 35 for the 2003 spill season.

The web site: http://www.nwd-wc.usace.army.mil/TMT/ contained NMFS regional forum TMT documents that outlined the rationale for determining which Columbia River projects to spill at and in what order.

The spring spill program in the Lower Columbia River started April 14 for McNary, John Day, The Dalles and Bonneville dams. The spring spill program for these projects ended on June 20. The 2000 NMFS BiOp calls for spilling forty (40) percent of the project outflow at The Dalles, but at no time is the project to spill more than the 120% gas cap voluntarily.

Summer Spill
The Summer Spill Program was characterized by below average river flows, which resulted in spill formally discontinuing at McNary on June 20th. Although McNary spill formally discontinued spill, the project continued to intermittently spilled between 0 and 98 kcfs for the next nine days when the total project outflow exceeded hydraulic capacity. Spill also continued at Ice Harbor, John Day, The Dalles and Bonneville until August 31. There was no summer spill at Lower Granite, Little Goose and Lower Monumental.

Spring Creek Hatchery Spill
Spill occurred at the Bonneville dam during the second week of March to facilitate 6 –7 million juvenile Tule fall Chinook salmon passage. Spring Creek National Hatchery is located in Underwood, Washington upstream from Bonneville dam. Prior to the release, the US Fish and Wildlife Service obtained a TDG variance from Oregon DEQ that allowed for elevated TDG levels associated with the spill operation. However, after obtaining this waiver from the State of Oregon, it was determined that the spill levels anticipated would not exceed the 110% TDG levels, therefore no waiver was sought from the State of Washington. From March 10 to 12, 2003, there was 50 to 52 kcfs spill released from Bonneville dam resulting in 103 to 105% TDG levels as measured at the Warrendale FMS.

2.2.1.1 Special Spill Operations
During 2003, there were five spill operations that were considered special because they were outside of the NMFS' 2000 BiOp. They were also considered special because they are tests with spill levels that were either higher or lower than those specified in the BiOp. The Corps developed the following tests, coordinated them through the Studies Review Work Group (SRWG), and interacted with NOAA Fisheries to obtain their concurrence. These tests were:

1. Lower Granite dam removable spillway weir test
2. Ice Harbor spill tests
3. John Day summer fish spill tests
4. The Dalles balloon tag test
5. Bonneville juvenile fish passage test

Lower Granite Dam Removable Spillway Weir Test
The primary purpose of the removal spillway weir (RSW) test was to determine the effects of using the RSW on juvenile fish passage and survival. Test spill operations caused wide fluctuations in the TDG levels. The Lower Granite RSW test went from April 14 to May 30 with spill operations varying from spilling using the RSW to following the 2000 BiOp spill regime. Spill using the RSW resulted in a 20 kcfs spill for 24 hours with 110 to 111% TDG. Spilling to the BiOp spill levels resulted in 12 hours per day of approximately 41 kcfs spill with TDG levels between 116 to 120 %. The test was designed using a randomized block design.

Ice Harbor Spill Test
The primary purpose of the spring spill test was to determine the effect of different spill levels on juvenile fish passage and survival. The researchers tried several different test conditions in an attempt to find a test condition that provided the best juvenile fish passage and survival results. Because of their difficulty in finding an acceptable test condition, three tests were performed: the spring test, the summer test, and the balloon tag test.

Spill for the Ice Harbor Spill spring spill test lasted from April 23 to June 23 and varied from BiOp spill to the test conditions. BiOp spill was spilling 45 kcfs during the day and during the nighttime, spilling to the gas cap or the project outflow, which ever is greatest. Test conditions were spilling 50% of the project outflow. On 6/13 and 6/23 from 1300 – 1600 hrs, spill was limited to bays 4 through 6 in order to remove and then reinstall some equipment. Several different spill patterns were tested in order to see the effects the different patterns had on juvenile fish mortality and injury. This test produced TDG levels fluctuations between 109 and 118% as shown on Figure C-15 of appendix C.

Summer spill test was performed from June 24 through July 17. Several different spill patterns were tested in order to investigate the effects the patterns had on juvenile fish mortality and injury. From 6/24 to 7/16 spill was alternated between the BiOp spill using a bulk spill pattern and no spill. Spilling with the bulk spill pattern was accomplished using wider gate openings with a reduced number of bays. In response to the initial results, the test was modified to include the test conditions of BiOp/Bulk spill and no spill. This test produced wide TDG levels fluctuations between 100 and 118% as shown on Figure C-15 of appendix C.

On July 15 a balloon tag test occurred in the spillway. On 7/17 spill was changed to spill from 2000 – 0800 and no spill from 0800 – 2000. This test was to determine the effect of these changes of juvenile fish passage and survival. Spill ended 8/31 2400. This test also produced wide TDG levels fluctuations between 100 and 118% as shown on Figure C-15 of appendix C.

John Day Dam Fish Passage Spill Tests
There were two fish tests during the 2003 spill season at John Day: the spring and the summer fish test. The spring fish test began on April 24 and lasted through June 9. The primary purpose of this fish passage spill test was to determine the effect of different spill levels on fish passage and survival. The fish passage spill test alternated between 60% or

40% of the project outflow at night to no daytime spill. The test was designed using a randomized block design. This test produced TDG levels fluctuations between 107 and 120% as shown on Figure C-21 of appendix C.

The summer fish test began on June 22 and lasted through July 21. The primary purpose of this fish passage spill test was to determine the effect of different spill levels on fish passage and survival. The special spill operations at John Day caused wide fluctuations in the TDG levels. Spill for the John Day fish passage spill test varied from 30% of the project outflow for 24 hours to 60% of the project outflow at nighttime and 0% during the day. Spilling 30% of the project outflow resulted in a 30 to 90 kcfs spill for 24 hours with 113 to 120% TDG. Spilling to 60% of the project outflow for 12 hours resulted in a 100 - 165 kcfs spill with TDG levels between 115 to 118 %. The test was designed using a randomized block design. This test produced TDG levels fluctuations between 107 and 120% as shown on Figure C-21 of appendix C.

The Dalles Balloon Tag Test
The primary purpose of the balloon test was to determine effects of different gate openings in spill patterns on the fish survival. Spill for The Dalles balloon test was 40% of the project outflow with the spill patterns varying from May 20 to June 10. Spilling 40% of the project outflow resulted in a 100 to 160 kcfs spill for 24 hours with 115 to 120% TDG. The test was designed using a randomized block design.

Bonneville Fish Passage Spill Test
The primary purpose of Bonneville fish passage spill test was to determine the effect of different daytime spill levels on adult passage. Spill for the Bonneville fish passage spill test varied from 75 kcfs to the gas cap of 120% during the day from April 14 to June 28. Spilling 75 kcfs spill for 12 hours resulted in 108 to 112% TDG. Spilling to the gas cap for 12 hours resulted in a 120 – 156 kcfs spill with TDG levels between 115 to 120 %. The test was designed using a randomized block design.

2.2.1.2 Voluntary and Involuntary Spill

The Corps Reservoir Control Center staff developed BiOp Spill graphics in 1998 for daily operational monitoring of BiOp spill and has used them since. The Corps calculates the amount of BiOp spill, which is a part of voluntary spill, and those calculations and graphs are included in this report as Appendix F. The BiOp spill can be compared to the TDG levels by using Appendix C, which contains graphs of spill, flow, and TDG for the Snake and lower Columbia River projects.

The BiOp spill graphs in Appendix F show Lower Granite and McNary projects had significant amount of spill above the BiOp spill levels from May 22 to June 22, 2003. This involuntary spill was associated with high runoff and river flows on the Snake River. Of the Columbia and Snake River projects, McNary had the most spill above the BiOp spill level which may be related to limited hydraulic capacity.

Involuntary spill occurred on the Snake and Columbia River projects from May 26 through June 6. On May 29 the freshet peaked and 14 out of a possible 18 FMSs exceeded the

115/120% gas cap. John Day tailwater FMS is the only gage that experience no exceedances during the 2003 spill season. Involuntary spill was especially pronounced on the Snake River. From May 27 through June 6, the tailwater FMS at Lower Granite; Little Goose; Lower Monumental; Ice Harbor; and the Lower Monumental forebay FMS exceeded the 12 hours average TDG 125% gas cap. Graphs of the Snake and Columbia River projects' 12 hours average TDG levels shown in Appendix G illustrate the impact of involuntary spill levels on TDG levels during the May 26 to June 6 period.

On June 21, there was involuntary spill at Chief Joseph dam when six units went down. Because Chief Joseph lacked generation capacity, Grand Coulee had to generate more power, which resulted in more water being released out of Grand Coulee than typical. When the extra water arrived at Chief Joseph, it had to be spilled which resulted in TDG levels exceeding the 125% gas cap. Chief Joseph and Libby flood control operations are described in Appendix K.

There were two maintenance efforts at Little Goose that resulted in involuntary spill and TDG levels above 140%. On June 3 and 11, the project opened one of the gates to release debris that had collected in the river from the high river flows. Opening the gate to pass debris resulted in hourly TDG levels of 142.7 and 148.0% on June 3. There was also an hourly reading of 145.4% TDG on June 11.

There was a maintenance effort at Bonneville that resulted in involuntary spill and high TDG levels. One bay gate was left open for seven hours on May 28-29, releasing significant amounts of spill resulting in TDG levels between 125 and 129%.

Additional involuntary spill occurred from April 10 through April 15 at Dworshak Dam resulting in 5 hours of TDG exceedances of the 110% gas cap. By June 20, the reservoir almost reached its maximum pool elevation of 1600 ft. Releases were increased and as shown on the Dworshak TDG hourly data graph in Appendix C, but even with the increased outflows, the TDG levels were maintained between 103% and 105%. As Table 2 shows TDG exceedances at Dworshak during 2003 ranged from 110.1 to 113.7.

It may be helpful to consider the TDG exceedances from a general overall annual perspective. As Table 2 shows, the hours and percent of time of exceedances for 2003 at Dworshak were much lower than 2002 even though the amounts of precipitation for both water years were similar. In 2003 Snake River upstream of Ice Harbor Dam was 89 percent of normal (1971-2000) and in 2002 the Snake River upstream of Ice Harbor Dam was 82 percent of normal (1971-2000). Even though the amount of precipitation was similar, the shape of the runoff was different, which resulted in a consistent gradual spill/release at Dworshak in 2003.

TABLE 2
SUMMARY OF ANNUAL TDG EXCEEDANCES
AT DWORSHAK DAM

Year	No. of Hours Exceedances	Range of Exceedances	Possible No. of Hours Exceedances	Hours Spill Occurred	% of Hours in Exceedance	% of Hours Consistent w/Standards
2003	15	110.1 to 113.7	3312	1798	0.83	99.4
2002	262	110.6 to 119	3312	2684	8	92.0
2001	2	110.1	3312	0	0.06	99.9
2000	146	114.2 - 110.1	3312	1776	8.2	91.8
Before 2000	Not Calculated	Unknown	Unknown	Unknown	Unknown	Unknown

2.2.2 Dworshak Releases

From early July through mid September, water releases from Dworshak Dam were adjusted and used to cool the lower Snake River. Water releases from Dworshak Dam for this purpose began on July 3, 2003 when Dworshak forebay elevation was at 1599.6 ft and continued until September 12, when the forebay elevation of 1520 ft was reached. An outflow of approximately 1.5 kcfs/hr was continued thereafter. TMT requested that the project outflow be 45^{o} F. Calculations of how long 45^{o} F water could be maintained were prepared and can be found in Appendix D. These calculations are similar to those used in 2002 except for using slightly modified assumptions. Based on these calculations, there was enough water in the Dworshak reservoir to maintain 45^{o} F temperature for approximately 12 weeks. The volume of water to be released would be depleted before the 45^{o} F water would be depleted. Cool water releases began on July 11, 2003 and continued until September 12.

Appendix D contains graphs showing the influence of Dworshak outflow releases and water temperature measured at the Lower Granite tailwater FMS. The benefit of the cold-water releases can be clearly seen in the Lower Granite tailwater temperature monitoring.

In 2003, the Lower Granite tailwater daily average water temperature exceeded the 68^{o} F State standard for two days: 68.1 ^{o} F on July 10 and August 30. A 5 kcfs water release from Dworshak Dam began on July 3. A water temperature change of 48 ^{o}F began on July 2. The 5 kcfs outflow with 48 ^{o}F water did not significantly affect the Lower Granite tailwater daily average water temperature. Figure D-1 in Appendix D shows that on July 7, the water releases was increased to 10 kcfs and 48 ^{o}F water maintained. The daily average water temperature at Lower Granite tailwater dropped by July 12, which harmonizes with the travel time for the river mass to travel from Dworshak to Lower Granite. It takes approximately five days for the river mass to travel from Dworshak to Lower Granite when there is a total river flow of 50 kcfs on the Snake and 5 kcfs on the Clearwater. The river mass travel time is less if the total river flows are higher. The Dworshak flow augmentation continued to maintain Lower Granite tailwater daily average water temperature below 68 ^{o}F, until the Dworshak flow augmentation was dropped from 10 kcfs to 7 kcfs on August 19. With the five-day travel time and warm weather, the

Lower Granite tailwater daily average water temperature began to rise on August 23 and peaked on August 30.

The Lower Granite forebay daily average water temperature exceeded 68^{o} F for approximately 56 days beginning on July 7, which was considerable longer than in 2002 when water temperatures exceeded 68^{o} F for approximately 21 days. Exceeding water temperatures in the Lower Granite tailwater for two days is much less than 2002, when there were approximately eight days of temperature exceedances. The fact that the 2003 Lower Granite tailwater temperature had less temperature exceedances in 2003 than 2002 while the Lower Granite forebay had three times the number of days exceeding 68^{o} F can be credited to the fact that there were nine weeks of 45 ^{o}F Dworshak water releases in 2003 compared to only 2 weeks in 2002.

Part 3 Program Results

3.1. Water Quality Review

3.1.1 Total Dissolved Gas

Operation of the Federal Columbia River Power System (FCRPS) to meet multiple purposes often necessitates spill operations that can result in exceedances of state water quality standards for TDG. The Corps, in accordance with the NMFS Biological Opinion, voluntarily spills for fish passage. In addition, spill at Corps projects occurs there are physical or mechanic circumstances that necessitate it. For instances, when powerhouse capacity is exceeded, the intertie lines need repair, unit outages, or just passing debris, water is released through the spillway resulting in increased TDG levels.

The NMFS 2000 BiOp and applicable voluntary spill for fish program was implemented consistent with the State water quality standards variances. During the spill season, the TDG level in the project forebays and tailwaters was monitored. Adjustments, when necessary, were made to the upstream project spill levels to maintain the average of the 12 highest values in 24 hours in project forebays at less than 115% TDG and the average of the 12 highest values in 24 hours in project tailwaters at less than 120%.

2003 TDG Exceedances:

Washington and Oregon state standards during the 2003 spill season were exceeded 243 days at the projects on the Lower Columbia and Snake rivers out of a possible 3,020 days (number of projects x days in spill season). Table 3 provides a summary of TDG exceedances during 1999-2003 spill seasons. The 243 exceedances during 2003 spill season includes both voluntary and involuntary TDG exceedances as shown on Table M-2 in Appendix M. The high 12-hour average of TDG levels for the forebay and tailwater of each Corps project was daily tracked during the 2003 spill season and Table M-1 in Appendix M is a summary of the results. The forebay TDG exceedances varied from 115.1 to 128.7%. The tailwater TDG exceedances varied from 120.1 to 148.0%.

As Table 3 shows, the Ice Harbor forebay, Camas/Washougal forebay, and the McNary forebay FMSs had almost the same number of exceedances during 2003 and were the most difficult to maintain within the 115% TDG standard. During 2003 Ice Harbor forebay site had the most TDG exceedances of the FMS system monitoring stations with 35 exceedances. As Table 3 shows, the Camas/Washougal simulated forebay site had 33 exceedances. Camas/Washougal is typically a location with a higher number of exceedances than other FMS locations as Table 3 shows. The McNary forebay location on the Oregon side had 32 exceedances, which were attributed to the effects of solar radiation on water temperature and TDG levels. Refer to Appendix K for the Seattle District TDG Report discussion on Chief Joseph and Libby. Refer to Appendix I for the U. S. Geological Survey (USGS) discussion of the John Day, The Dallas, Bonneville, Warrendale and Camas/Washougal site. Refer to Appendix J for the Walla Walla District TDG Report discussion of all other sites. (It is a CD)

Appendix E contains a listing of the maximum and minimum TDG values measured at each FMS for each month of the spill season as well as the number of hours and days the TDG standards were exceeded each month.

There were instances of voluntary and involuntary spill at Dworshak. Idaho state standards were exceeded for 15 hours at Dworshak from April 10 to July 21, 2003 when spill for flood control, maintenance activities or cool water releases were necessary. The releases through the Dworshak Dam powerhouse were monitored and maintained at levels that would not generate TDG above the State standard.

Comparison of Annual Exceedances

Tables 4A and 4B provides a summary comparison of the total number of voluntary and involuntary spill related TDG exceedances for 1999 through 2003. There are two tables because the numbers of spill days are calculated two different ways. Table 4A shows the comparison as it was typically calculated using April 15 to August 31 as the spill season. Table 4B is a new approach where the spill days are calculated based on when spill season actually begins according to the Biological Opinion, which is April 3 through August 31.

As shown on Table 4A and B, the 1999 – 2003 five year average of TDG exceedances during a spill season is 282 exceedances, which includes both voluntary and involuntary spill exceedances. The 2003 spill season occurrence of 243 TDG exceedances is 86% of the five year average. This “lower than average” TDG exceedance rate is attributed in part to a lower than average water year precipitation. The 2003 water year precipitation was 80 percent of normal (1971-2000) above Grand Coulee Dam, 89 percent of normal in the Snake River above Ice Harbor Dam, and 85 percent of normal in the Columbia River above The Dallas, Oregon.

TABLE 3
1999 - 2003 SPILL SEASONS
NUMBER OF TDG EXCEEDANCES

	2003	2002	2001	2000	1999
Water Quality Gages	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**
Lower Granite Forebay	0	0	5	2	0
Lower Granite Tailwater	15	17	0	4	15
Little Goose Forebay	10	17	0	2	39
Little Goose Tailwater	6	6	0	9	6
Lower Monumental Forebay	19	49	0	28	44
Lower Monumental Tailwater	10	6	0	12	26
Ice Harbor Forebay	35	24	0	34	44
Ice Harbor Tailwater	4	6	0	4	12
McNary Forebay - Wa.	24	43	1	14	22
McNary Forebay - Or.	32	45	5	22	19
McNary Tailwater	12	31	0	17	50
John Day Forebay	10	11	0	1	8
John Day Tailwater	0	29	0	12	43
The Dalles Forebay	11	18	0	5	1
The Dalles Tailwater	4	11	0	5	5
Bonneville Forebay	17	30	0	14	19
Warrendale	1	19	0	6	2
Camas/Washougal	33	65	2	58	51
Chief Joseph Forebay	0	53	0	3	4
Chief Joseph Tailwater	0	11	0	0	1
Total Number of Exceedences	**243**	**491**	**13**	**252**	**411**

TABLE 4A
SUMMARY COMPARISON OF EXCEEDANCES
WITH PREVIOUS YEARS

Year	Days In Spill Season	Number of Days Exceeded	Percent Exceeding TDG Standard (%)	Percent Consistent With TDG Standard (%)
2003	2760	243	8.8	91.2
2002	2760	490	17.8	82.2
2001	2760	13	0.5	99.5
2000	2760	252	9.1	90.9
1999	2760	411	14.9	85.1
Average	**2760**	**282**	**10.21**	**89.79**

Note: Number of spill days are based on 20 gages X 138 days from April 15 - August 31.

TABLE 4B
SUMMARY COMPARISON OF EXCEEDANCES WITH PREVIOUS YEARS

Year	Days In Spill Season	Number of Days Exceeded	Percent Exceeding TDG Standard (%)	Percent Consistent With TDG Standard (%)
2003	3020	243	8.0	**92.0**
2002	3020	490	16.2	**83.8**
2001	3020	13	0.4	**99.6**
2000	3020	252	8.3	**91.7**
1999	3020	411	13.6	**86.4**
Average	**3020**	**282**	**8.26**	**91.74**

Note: Number of spill days are based on 20 gages X 151 days from April 3 - August 31.

Type of TDG Exceedances

During 2002 spill season, TDG exceedances were caused by a number of reasons. The Corps Reservoir Control Center developed a list of conditions related to FMS exceedances during 2002 and applied them to the 2003 spill season. These conditions were divided into types and tracked during the 2003 spill season as shown on Table 5.

TABLE 5
2003 SPILL SEASON
TYPES AND NUMBER OF TDG EXCEEDANCES

QUANTITY	TYPE #	DEFINITION
106	6	Exceedance due to uncertainties when using best professional judgment to apply the spill guidance criteria (travel time; degassing; water temperature
68	1	Exceedance due to high runoff flows and flood control efforts.
33	12	Exceedance due to sharp rise in water temperature (a 3 to 5 degree F. change in a day).
20	11	Exceedance due to high TDG levels coming from the Ice Harbor Dam.
18	7	Exceedance due to high TDG levels coming from the Priest Rapids Dam(see Pasco FMS readings).
7	9	Exceedance due to lack of information: the FMS gage malfunctioning and we had no information at the time of making spill change decisions.
9	10	Exceedance due to mechanical problems (gate was stuck open, passing debris etc.).
1	5	Exceedance due to a break down in communication. Teletype went out but no change occurred or Project operator interpreted teletype differently
0	2	Exceedance due to Intertie line outages.
0	3	Exceedance due to unit outages during repair or maintenance.
0	4	Exceedance due to BPA inability to handle load so water was spilled.
0	8	Exceedance due to a load rejection. The powerhouse was not working and the river was spilled.

As Table 5 shows, the most common condition related to exceedances was "uncertainties when using best professional judgment to apply the spill guidance criteria (travel time; degassing; water temperature effects; spill patterns)." This was exceedance type 6 which had 106 occurrences, representing 45.5% of the total number of exceedances. The second most common condition related to TDG exceedances was "high runoff flows and flood control efforts." This was exceedance type 1 which had 68 occurrences, representing 26% of the total number of exceedances. The third most common condition related to TDG exceedances was a "sharp rise in water temperature (a 3 to 5 degree F. change in a day)." This was exceedance type 12 had 33 occurrences, representing 12.6% of the total number of exceedances. A small number of exceedances were attributed to high TDG levels coming from the Ice Harbor or Priest Rapids dams, lack of information when the FMS gage malfunctioned, mechanical problems, and a break down in communication. Although Table 5 shows no exceedances associated with intertie line repairs or lack of load, these resulted in TDG exceedances during the 2002 spill season.

3.1.2 Water Temperature

The water temperature standards for the states of Idaho, Oregon, and Washington are shown below in Table 6.

TABLE 6
STATE WATER QUALITY STANDARDS
CHIEF JOSEPH DAM

Project	Washington Standard	Oregon Standard	Idaho Standard
Chief Joseph Dam, Columbia River, RM 545.1	"Temperature shall not exceed 18° C (64.4 F) due to human activities. When natural conditions exceed 18° C (64.4 F) no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3° C (0.5 F). Incremental temperature increases resulting from point source activities shall not, at any time, exceed t=28/T+7). Incremental increase resulting from nonpoint source activities shall not exceed 2.8° C (5.4 F)." WAC 173-210A-130(21) and WAC 173-201A-030(2)	None	None

TABLE 6 con't
STATE WATER QUALITY STANDARDS
THE LOWER SNAKE PROJECTS

Projects	Washington Standard	Oregon Standard	Idaho Standard
Lower Granite Dam, Snake River, RM 107.5 **AND** Little Goose Dam, Snake River, RM 70.3 **AND** Lower Monumental Dam, Snake River, RM 41.6 **AND** Ice Harbor Dam, Snake River, RM 9.7	"Temperature shall not exceed 20° C (68 F) due to human activities. When natural conditions exceed 20° C (68 F) no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3° C (0.5 F) nor shall such temperature increases, at any time exceed t=34/(T+9)." WAC 173-210A-130(98)(a)	None	Lower Snake – Asotin (Idaho/Oregon border) to Lower Granite Dam pool, Hydrologic Unit Code (HUC) 17060103, Rule Section 130.02. Aquatic Life: COLD (Cold Water Communities) "Water temperatures of twenty-two (22) degrees C or less with a maximum daily average of no greater than nineteen (19) degrees C."

TABLE 6 con't
STATE WATER QUALITY STANDARDS
THE LOWER COLUMBIA RIVER PROJECTS

Project	Washington Standard	Oregon Standard
McNary Dam. Columbia River, RM 292.0 **AND** John Day Dam, Columbia River, RM 215.6 **AND** Bonneville Dam, Columbia River, RM 146.1 **AND** The Dalles Dam, Columbia River, RM 191.5	"Temperature shall not exceed 20° C (68 F) due to human activities. When natural conditions exceed 20° C (68 F) no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3° C (0.5 F) nor shall such temperature increases, at any time exceed 0.3 C (0.5 F) due to a single source or 1.1° C (2.0 F) due to all such activities combined." WAC 173-210A-130(20)	From June 1 to September 30, "To accomplish the goals identified in OAR 340-041-0120(11), unless specifically allowed under a Department-approved surface water temperature management plan as required under OAR 340-41-026(3)(a)(D), no measurable (defined as 0.25° F) surface water temperature increase resulting from anthropogenic activities is allowed:…(ii)when surface water temperatures exceed 68° F (20.0° C)." (OAR 340-041-0205(2)(b)(A). From October 1 to May 31, , "To accomplish the goals identified in OAR 340-041-0120(11), unless specifically allowed under a Department-approved surface water temperature management plan as required under OAR 340-41-026(3)(a)(D), no measurable (defined as 0.25° F) surface water temperature increase resulting from anthropogenic activities is allowed:…(iii) In waters and periods of the year determined by the Department to support native salmonid spawning, egg incubation, and fry emergence from the egg and from the gravels in a basin which exceeds 55° F(12.8° C)…" (OAR 340-041-205(2)(b)(A).(v) In water determined by the Department to support or to be necessary to maintain the viability of the native Oregon bull trout, when surface water temperatures exceed 50.0°F (10.0°C);

Hourly water temperatures in the forebays and the tailwaters of the Corps projects are shown in Appendix H.

The NMFS 2000 BiOp calls for cold-water releases from Dworshak reservoir. These releases are to reduce and/or maintain cooler water temperatures in the Snake River in the July and August time period when ambient conditions would typically cause the temperature to rise above 68°F. As discussed in 2.2.2 Dworshak Releases, the Corps achieved the objective of drafting Dworshak from 1600 ft elevation to 1520 ft for water temperature reductions and flow augmentation on the Snake River. As discussed in Appendix D, the cold water releases produced the desired effect of reducing and maintaining cooler water temperatures on the Snake River.

3.1.3 Recurring High TDG Exceedances

There were three locations that were difficult to avoid TDG exceedances from voluntary and involuntary spill, leading to high recurring TDG exceedances in 2003. As the 2003 data in Table 3 shows, there were high recurring exceedance at Ice Harbor forebay, McNary forebay, Oregon side; and Camas/Washougal forebay. These three FMS sites have two similarities: all three are forebay FMS and the upstream dam spill 24 hours/day either to the 120% gas cap or an established limit. Lower Monumental is immediately upstream of Ice Harbor and spilled 50% of the project outflow for 24 hours/day when flows were below 75 kcfs during 2003 spill season. Ice Harbor spilled 45kcfs during the day and during the nighttime either the project outflow or to the 120% TDG gas cap which ever is the greatest. Bonneville spilled to the 120% gas cap at the nighttime and 75kcfs during the day.

A review of the 1999-2003 TDG exceedances summarized on Table 3 highlights that these three FMS sites and Lower Monumental forebay have a history of recurring TDG exceedances. Camas/Washougal had the most exceedances during 1999, 2000, and 2002 spill seasons; the second most exceedances during 2003 and 2001 spill seasons. By comparison, Camas/Washougal has the most TDG exceedances of all the FMS sites. Historical, Ice Harbor forebay, Lower Monumental forebay, and McNary forebay – Oregon side can have a significant number of TDG exceedances, but not to the same extent as Camas/Washougal.

3.1.3.1 Ice Harbor

As shown on Table 3, the Ice Harbor forebay had 35 days of exceeding the 12 hour average for TDG, the greatest number of TDG exceedances for the FMS system during the 2003 spill season. The high TDG water coming from Lower Monumental dam may have played a part in increasing the difficulty in managing the Ice Harbor forebay's TDG exceedances during 2003. During 2002 when Lower Monumental dam did not spill due to safety concerns, the TDG exceedances at Ice Harbor forebay were easier to manage and had a lower number of TDG exceedances as Table 3 shows. This suggests that 24 hour spill at Lower Monumental may have played a part in increasing the TDG exceedance management difficulties at Ice Harbor forebay.

3.1.3.2 Camas/Washougal

Historically, Camas/Washougal FMS site has had a high number of TDG exceedance and 2003 spill season continues in this trend. As shown on Table 3, the Camas/Washougal site had 33 days of exceeding the 12 hour average for TDG, the second most TDG exceedances for the FMS system during the 2003 spill season. The Camas FMS represents a theoretical forebay in the lowest reach of the Columbia River, a site that is influenced by tidal interactions. This site was also significantly affected by environmental conditions such as changes in gorge winds, barometric pressures, changes in daily solar radiation, which resulted in swings in water temperatures. The aquatic plants' production of oxygen is also believed to be involved in causing diurnal variations in TDG. Consequentially, these factors contributed to the difficulty in making adjustment on how much to spill at Bonneville and still remain at or below the 115 percent TDG limit at Camas/Washougal.

3.1.3.3 McNary Oregon Side

Historically, McNary forebay, Oregon Site FMS site has had a high number of TDG exceedance and 2003 spill season continues in this trend. As shown on Table 3, the McNary forebay – Oregon side had 32 days of exceeding the 12 hour average for TDG, the third most TDG exceedances for the FMS system during the 2003 spill season. The McNary forebay is at the confluence of the Snake and Columbia rivers and receives waters that have not been fully mixed. Consequently, the water coming from the mainstem Columbia on the Washington side of the river often contains different TDG levels and water temperatures from the water entering from the Snake River on the Oregon side. Solar radiation heated the warmer water coming from the Snake River further, resulting in wide water temperature swings and TDG levels that were difficult to manage.

3.2 TDG Monitoring Results

3.2.1 TDG – Average of the High 12 values in 24 hours

Consistency with state water quality standards for TDG in Oregon and Washington is based on the calculation of the average of the 12 highest values in a 24-hour period. Consistency with state water quality standards for TDG in Idaho is based on the instantaneous TDG level not exceeding 110%.

Appendix G contains graphs of the high 12 hour average TDG values for each monitoring station for the 2003 spill season. The graphs also include representation of the applicable standard (110% for Idaho stations, and Oregon and Washington forebays at 115% or tailwaters at 120%).

As shown on Table 3, there were a combined total of 243 exceedances of the average of the high 12 values in 24 hour measured at the FMS on all Columbia and Snake river projects. Lower Granite forebay and John Day tailwater were the only FMSs that did not exceed state standards for TDG during the 2003 spill season. As the 1999-2003 summary of TDG exceedances on Table 3 shows, no exceedances at Lower Granite forebay is somewhat typical.

3.2.2 TDG – Hourly flow, spill and TDG

Supersaturated water is a result of voluntary and involuntary spill at the projects. The graphs contained in Appendix C represent the hourly flow, spill, and TDG data for each monitoring station. These graphs show the relationship between elevated TDG levels and spill.

The Ice Harbor graph is a good representation of the relationship between spill and TDG. During the entire spill season, operations at the project were varying between 0 kcfs spill and 140 kcfs spill. The TDG fluctuations directly track the changes in spill.

Part 4 Fish Passage Summary

4.1 Biological Monitoring

The spill cap levels recognized in the 2000 Biological Opinion, and consistent with state and tribal water quality variances, are: a daily average (based on the12 highest hours) of 115 percent in the project forebays, a daily average (based on the 12 highest hours) of 120 percent in the project tailwaters, and a maximum high 2-hour average of 125 percent anywhere in the river. The NOAA Fisheries 2000 BiOp and the state TDG variances calls for biological monitoring for Gas Bubble Trauma Disease, which the Action Agencies performed in accordance with RPA action 131.

"Gas Bubble Trauma Monitoring and Data Reporting for 2002" by the Fish Passage Center is shown in Appendix L. Sampling of juvenile salmonids for gas bubble disease was conducted at Bonneville and McNary dams on the lower Columbia River, and at Rock Island Dam on the mid-Columbia River. The monitoring sites on the lower Snake River included Lower Monumental, Little Goose and Lower Granite dams. Sampling occurred two days per week at the lower Columbia River sites and once per week at the lower Snake River sites. Sampling of fish began the first full week of April at all sites and continued through mid-June at the Snake River sites. Sampling of subyearling Chinook occur at Columbia River sites to the end of August.

A total of 12,420 juvenile salmonids were examined between April and August 2003. A total of 104 or 0.8% showed some signs of gas bubble trauma in fins or eyes. Fin signs were found in 101 or 0.8% of the fish sampled at all sites. These were composed of 96 fish with rank 1 (up to 5% of the fin area), five fish had rank 2 (6 to 25% of the fin area) signs, and no fish had a rank of 3 (26 to 50% of the fin area).

At the lower Columbia and lower Snake dams operated by the Corps, a total of 10,112 juvenile fish were examined, with 54 or 0.5% exhibiting signs of gas bubble disease, compared to 0.7% in 2002, 0.1% in 2001, 0.2% in 2000, 1.4% in 1999, 1.6% in 1998, 4.3% in 1997, 4.2% in 1996 and 1.3% in 1995. No fish were found with severe fin gas bubble trauma.

The Biological Opinion Spill Program was managed using the data collected for total dissolved gas levels. However, signs of GBT in fins of juvenile fish, examined as part of the biological monitoring, were used to compliment the physical monitoring program. The NMFS set the action criteria for the biological monitoring program at 15% prevalence of fish having fin signs or 5% with severe signs (rank 3 or greater) in fins. The NMFS action criteria were never exceeded. This is similar to 2002, 2001, 2000, 1999, 1998 or 1995 when no exceedances occurred. But contrasts with 23 dates when GBT levels surpassed the action criteria in 1997, 20 in 1996.